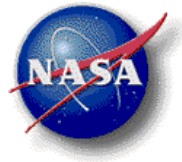
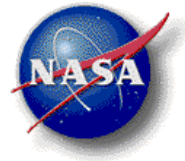


Groundwater Remediation and Alternate Energy at White Sands Test Facility

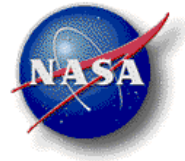
September 2008

Holger Fischer
Facility Operations



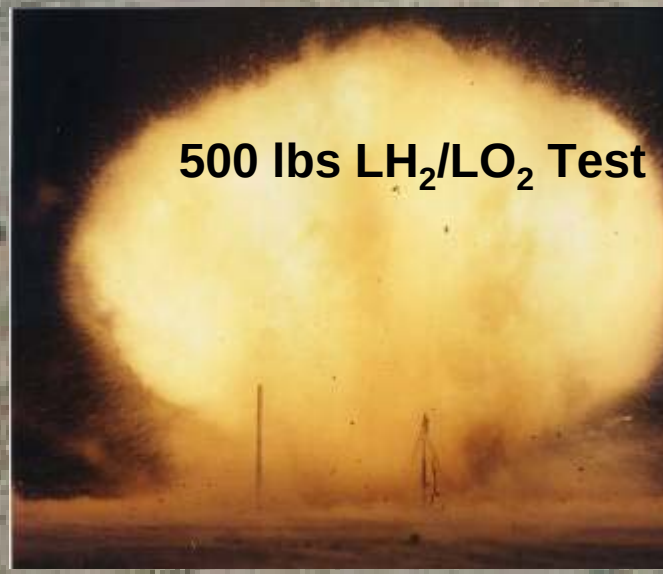
Content

- WSTF Core Capabilities
- WSTF Groundwater Remediation Program
- Alternate Energy Programs
  - Wind Energy
  - Solar Testbed
    - Solar
    - Vehicle Plug-in
    - Energy Storage
  - Utility Size Peak Shaving Solar Generation Plant

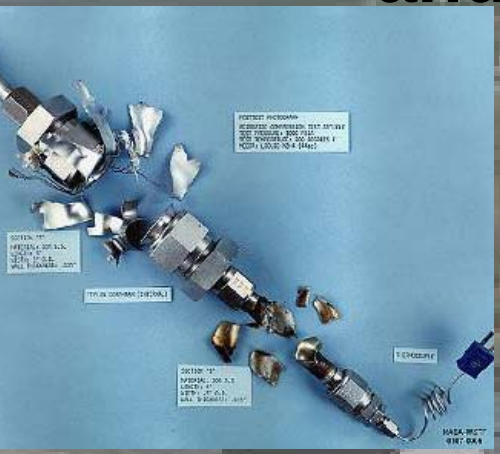


- WSTF Core Capabilities
  - Remote Hazardous Testing of Reactive, Explosive, and Toxic Materials and Fluids
  - Hypergolic Fluids Materials and Systems Testing
  - Oxygen Materials and System Testing
  - Hypervelocity Impact Testing
  - Flight Hardware Processing
  - Propulsion Testing

Remote Hazardous Testing of Reactive, Explosive, and Toxic Materials and Fluids



Hypergolic Fluids Materials and Systems Testing

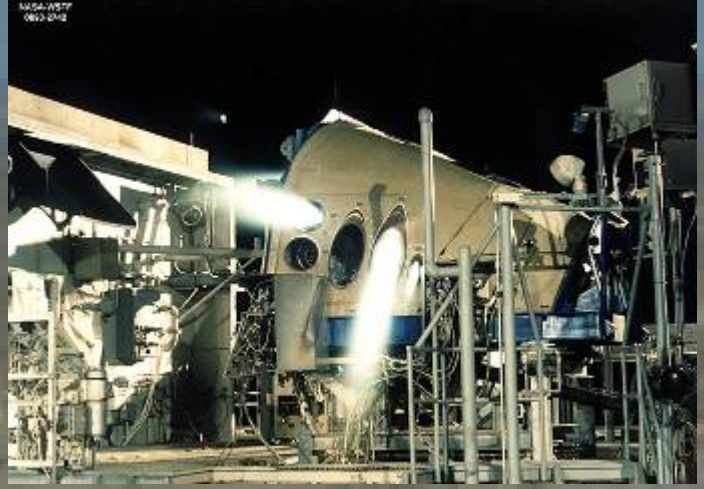


NHB 6001 Test

Evaporation Tank

Ignition Test

300 Propulsion Testing



Night firing of Shuttle Forward RCS primary and vernier thrusters

Night firing of Shuttle Aft RCS primary and 24 lb thrust vernier engines

400 Propulsion Testing

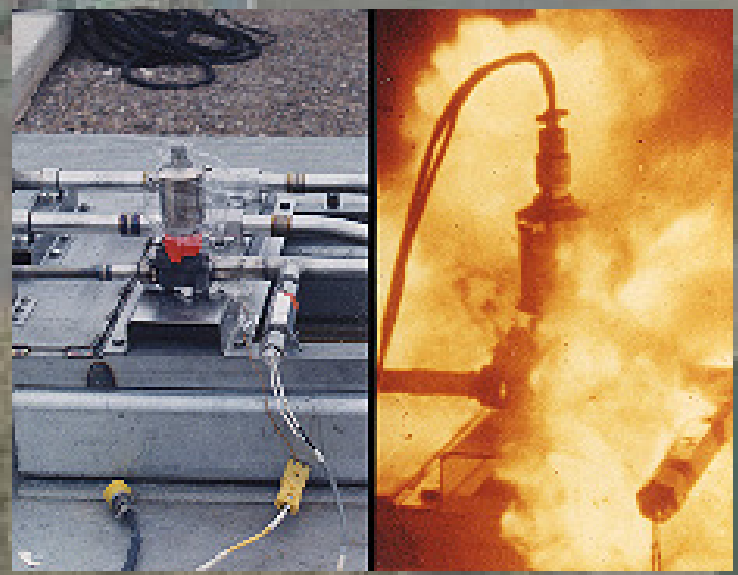
Static firing of DC-X with 4 LOX/Hydrogen RL10-A5 engines

500 Fuel **Treatment** Unit

Cassini - Saturn orbit insertion engine glows during 3 hr. 20 min. continuous firing

Flight Hardware Processing

Oxygen Materials and System Testing



Hypervelocity Impact Testing

Restoration Program

- Historic operations and practices beginning in the 1960's (through the early 1980's) resulted in contamination of WSTF's groundwater.
  - Propulsion system testing programs:
    - N-Nitrosodimethylamine (NDMA)
    - Dimethylnitramine (DMN)
  - Component Servicing and Cleaning Operations:
    - Trichloroethene (TCE)
    - Tetrachloroethene (PCE)
    - Freons: (11, 21, and 113)
- WSTF contaminated ground water is NASA HQ's greatest liability (estimated at $350M).

Restoration Program

- Priority: Protect the public's health and the health of our workforce.
  - Containment
    - Stop the migration of contaminated groundwater
    - Greatest health-risk liability pursued initially
      - Plume Front
      - Mid Plume
      - Source Areas
  - Restoration
    - Clean-up the environment to preexisting conditions

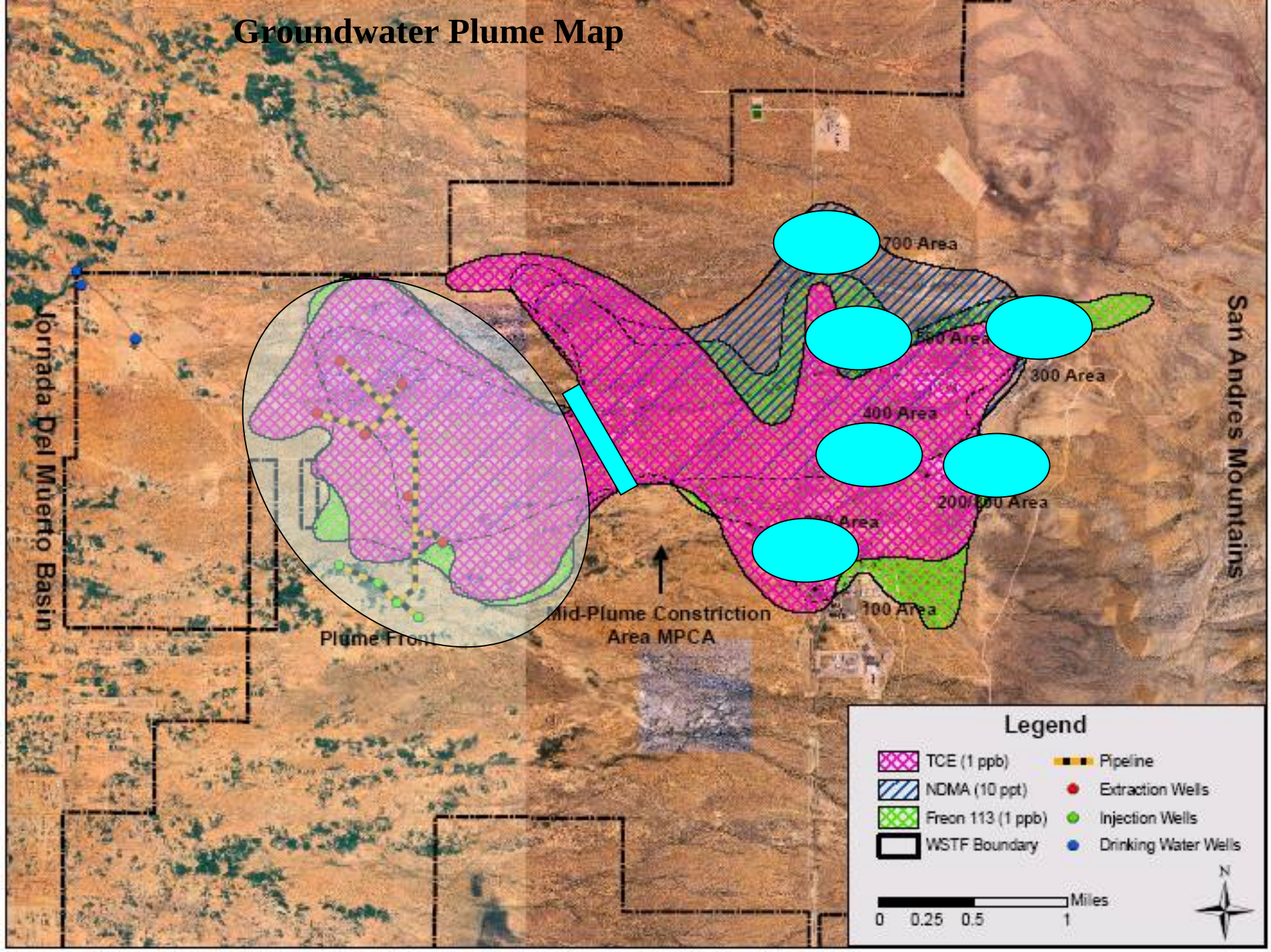
Public and Employee Assessment

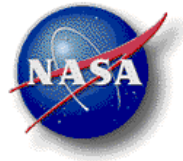
- There is no impact to any drinking water well
  - Includes public wells and the NASA supply well.
- There is no public exposure
  - Groundwater is several hundred feet below ground.
  - No air or surface water exposure.
  - Plume is moving very slowly to the west.
    - Plume Front Treatment system will stop this westward movement.
- NASA performs on-going monitoring
  - More than 200 wells and zones are routinely sampled.
  - ~850 samples are obtained monthly and analyzed for over 300 different hazardous chemicals.

Containment and Restoration

- A Staged Approach over ~60 years:
  - Attack the greatest risk to public health first
    - Stabilize the plume front (in progress)
  - Stop migration of contaminant into the plume front
    - Extraction and treatment at the Mid Plume Constriction Area (~2009)
    - 60% Review completed, 90% Review Oct 08
  - Stop migration into the Mid Plume Constriction Area
    - Clean up the source areas (~2012-2015)

Groundwater Plume Map





Extraction Wells

1 2 3 4A 5 7

Contaminated water containing nitrosamines and VOCs

Air Strippers

#1

#2

VOCs Removed

Water Filters

1

2

Particulate filtration

UV Tower

UV-Photolysis of Nitrosamines

Injection Wells

1

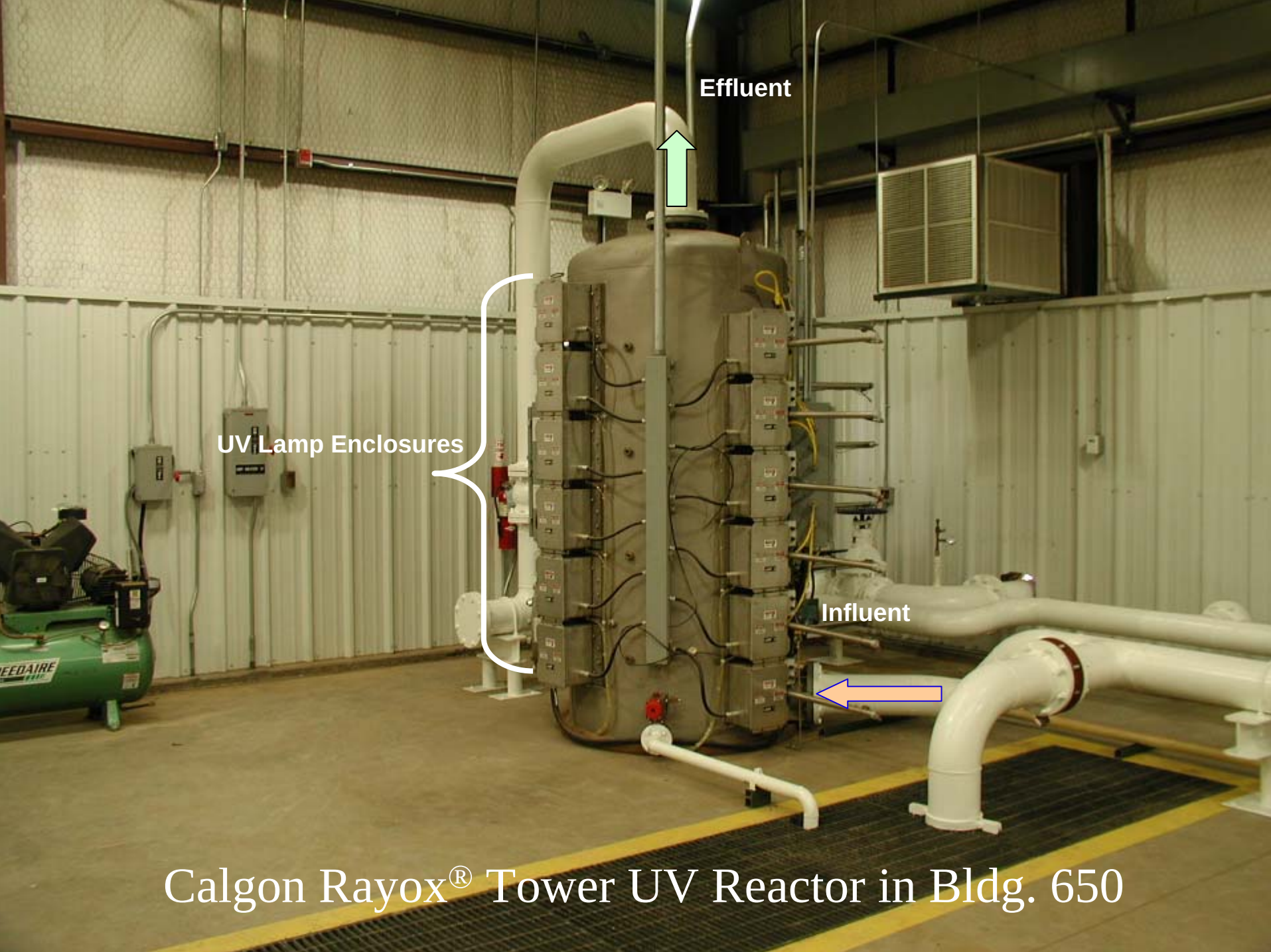
2

3

4

Treated water Injected back into aquifer

Plume Front Treatment System



Calgon Rayox® Tower UV Reactor in Bldg. 650

Alternate Energy

Alternate Energy

- Wind Energy:
  - Monitored Quartzite Mountain Range since about 2005 – 4 to 5 class wind site
  - Initial EA performed by WSTF Environmental
    - Bat study (Fall 2007/Spring 2009)
    - Radar issues with WSMR (formed working group with WSMR test ops)
    - Cost for road to access planned wind farm area about $ 5 – 6 M
  - Developers interested in constructing wind and solar
  - EPEC interested in future wind project

Alternate Energy

PV Parking Shade Structure

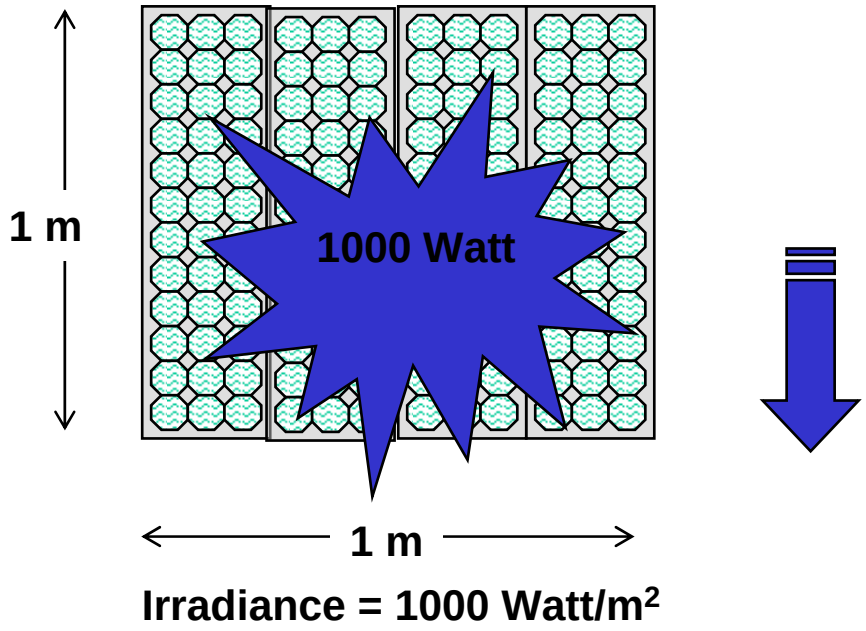
NMSU Shade Structure

Photovoltaic System

- Task order has been issued
- PV will provide peak shaving during daylight hours
- Charge storage batteries
- Batteries will provide peak shaving
- System will provide shading for vehicles in parking lot.
- Provide Plug-in for POVs
- Could be used for PV test bed
  - Installation of separate modules (different technologies)

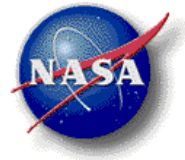
Efficiency of PV modules

- Commercial modules: 10-22%



Irradiance = 1000 Watt/m²

100 - 220 Watts
Electrical power



PV/BATTERY HYBRID SYSTEM

• The test bed renewable system will charge batteries throughout the day during off peak load demand and discharge batteries during peak load demand.

-Will determine the benefits of utilizing the Zinc-bromine batteries for utility peak shaving application.

-Includes evaluating the economic benefits of the system and monitoring the operation and performance of the PV and Batteries.

- Data will be collected to evaluate the overall system performance overtime and to verify the storage system operates when necessary and provide the necessary power required by end user.

Energy Storage Unit

50kWh Zinc Bromine
Battery module

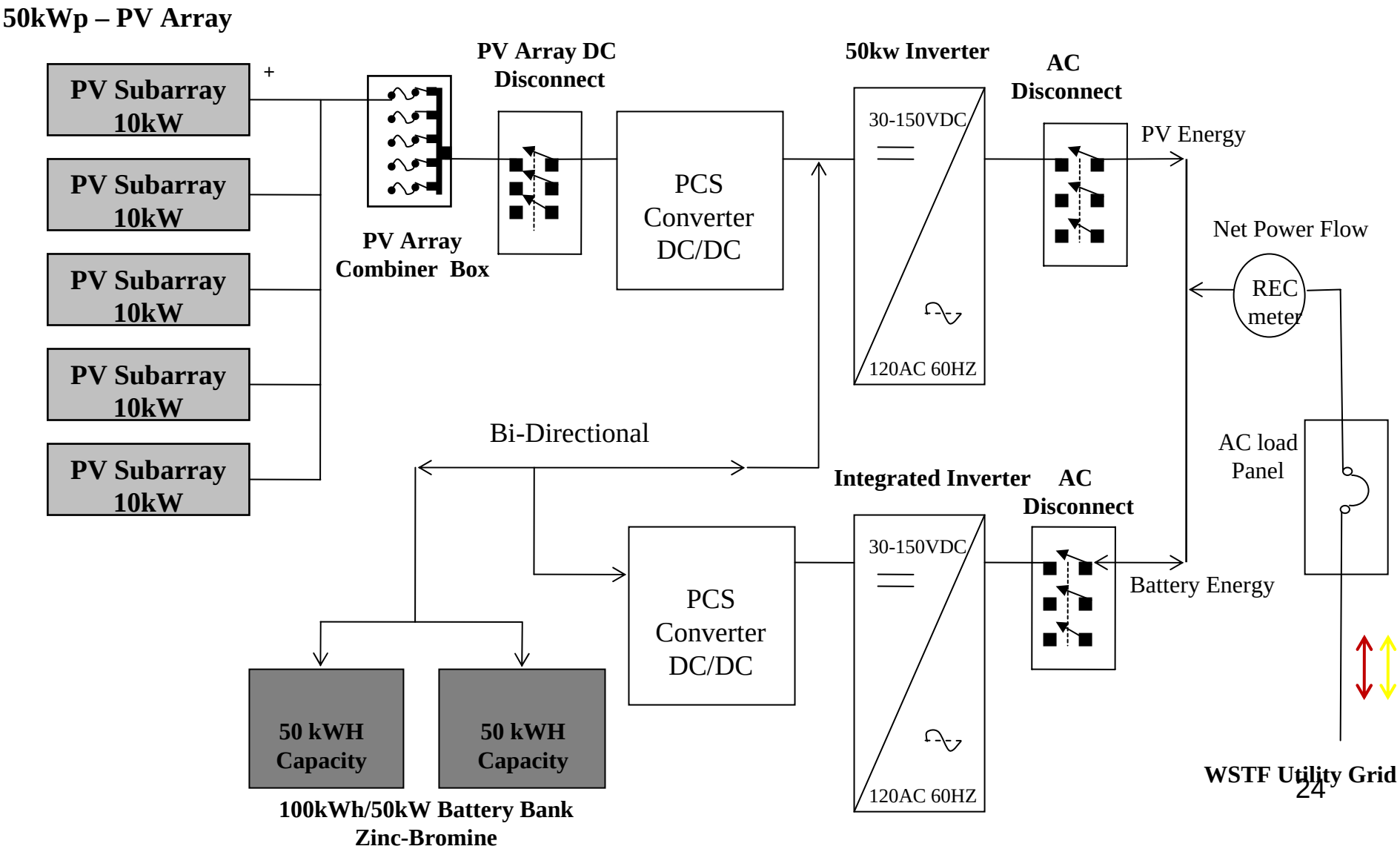
Battery Bank

- Two 50kWh battery modules connected electrically in parallel.
- A control system (Power Conversion System (PCS,inverter)
- A pair of electrolyte storage tanks.
- Electrolyte circulation equipment.

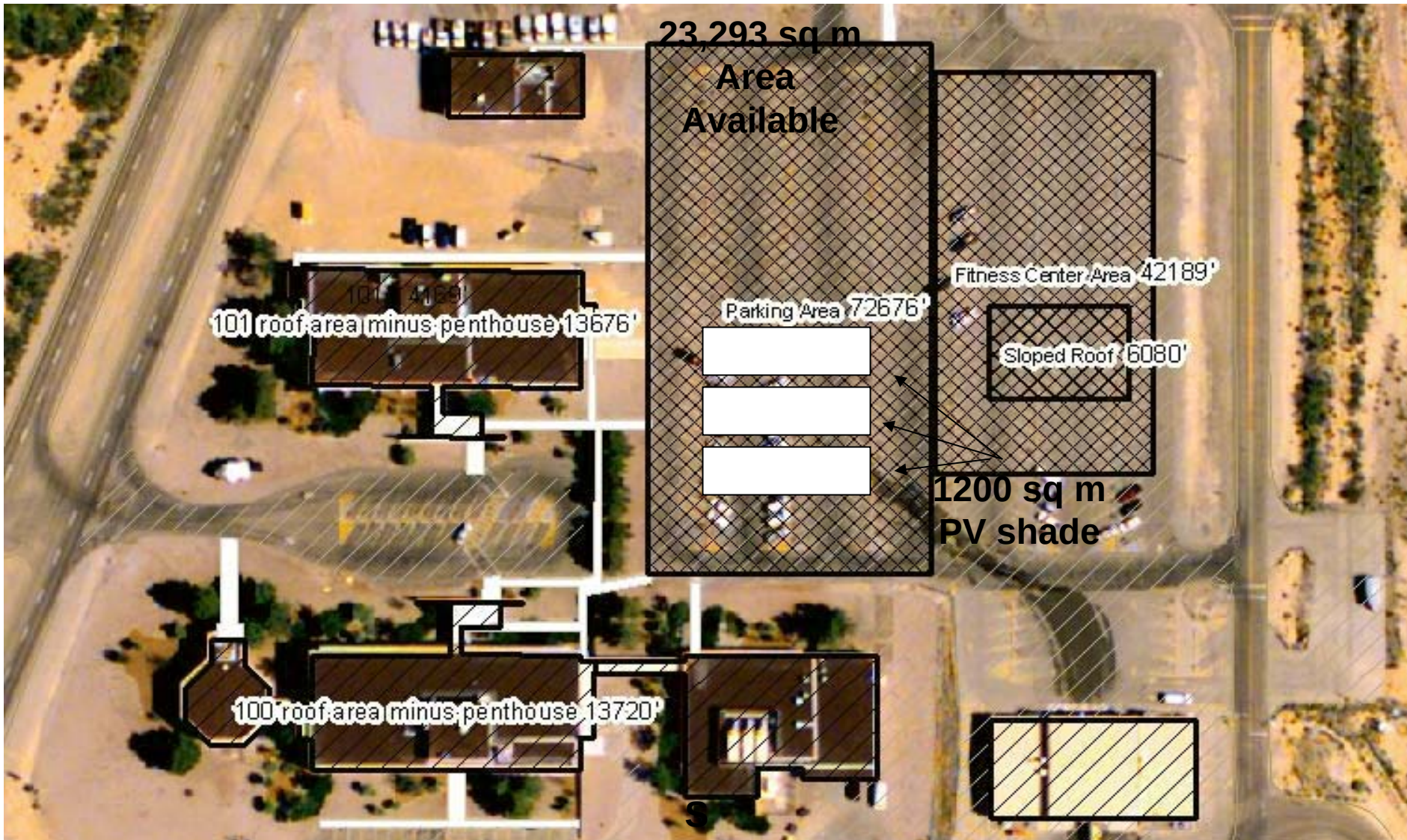
Advantages

- Uses electrodes that do not take part in the reactions consequently there is no material deterioration that would cause long term loss performance.
- Rapid recharge (two to four hours).
- Deep discharge capability (100%).
- Built in thermal management system.
- Can be used for large scale application.

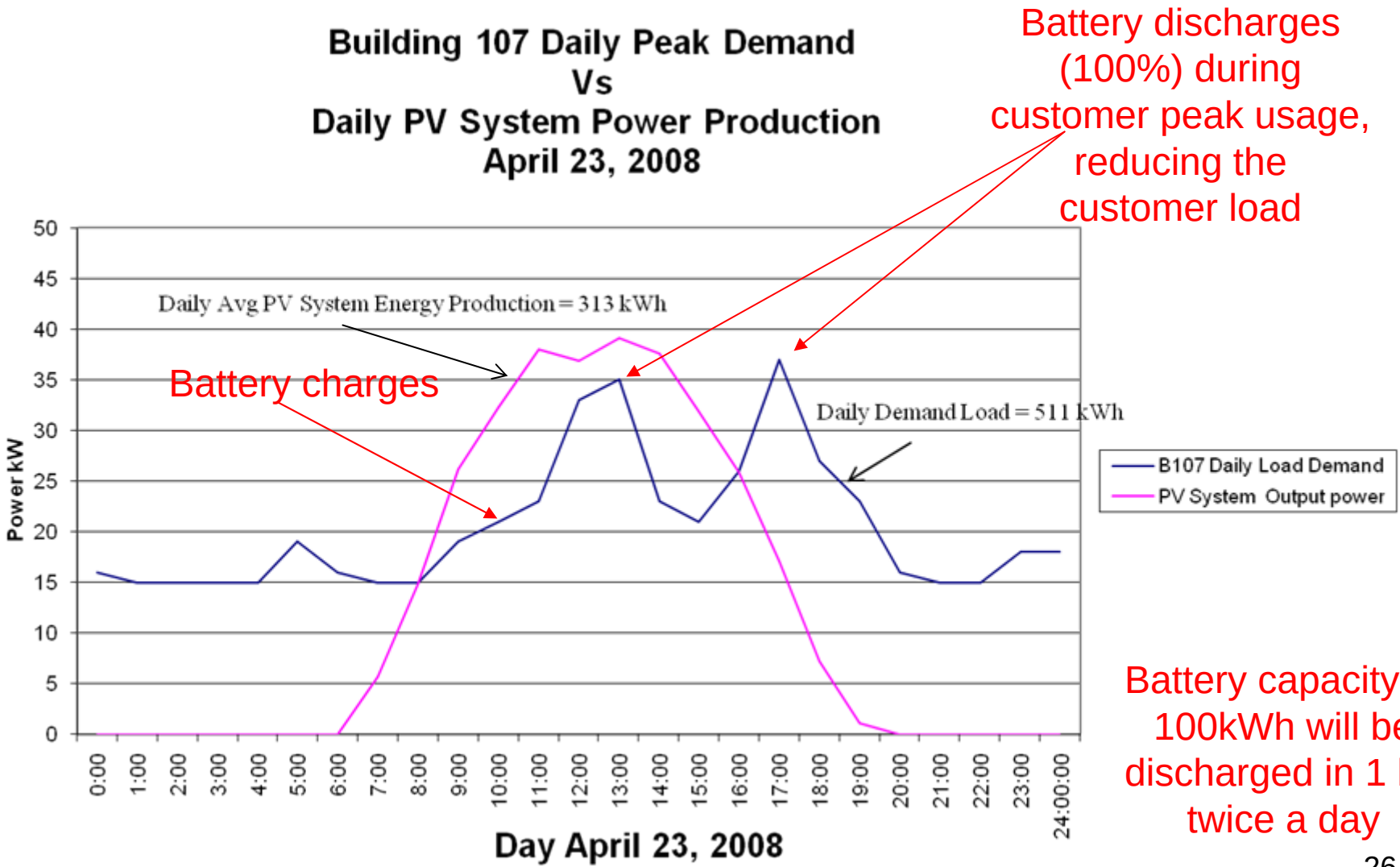
PV/Battery Hybrid System for Energy Storage Use



Shaded PV Structure Plan View

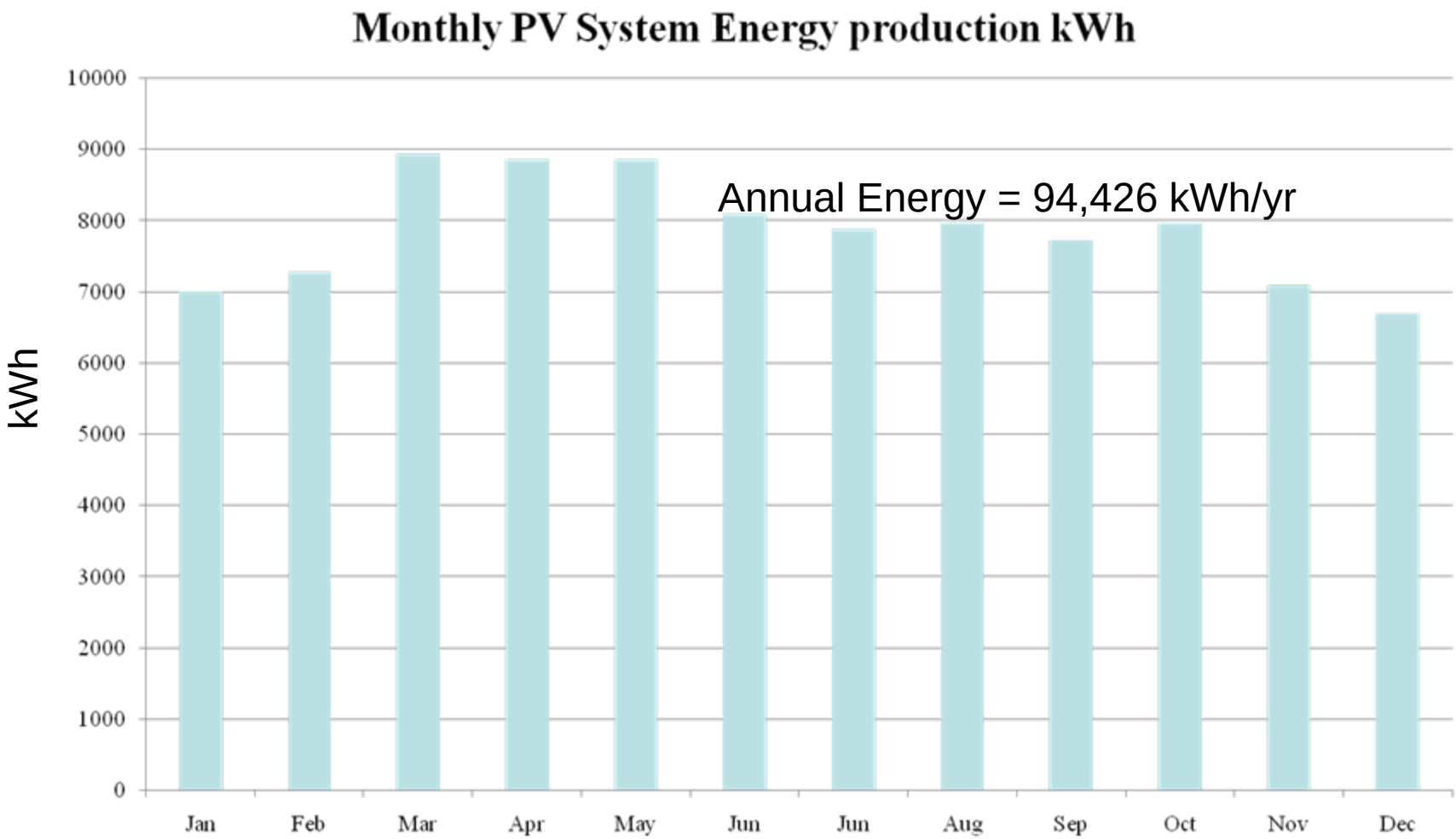


PV Power Coincides with Peak Demand Load

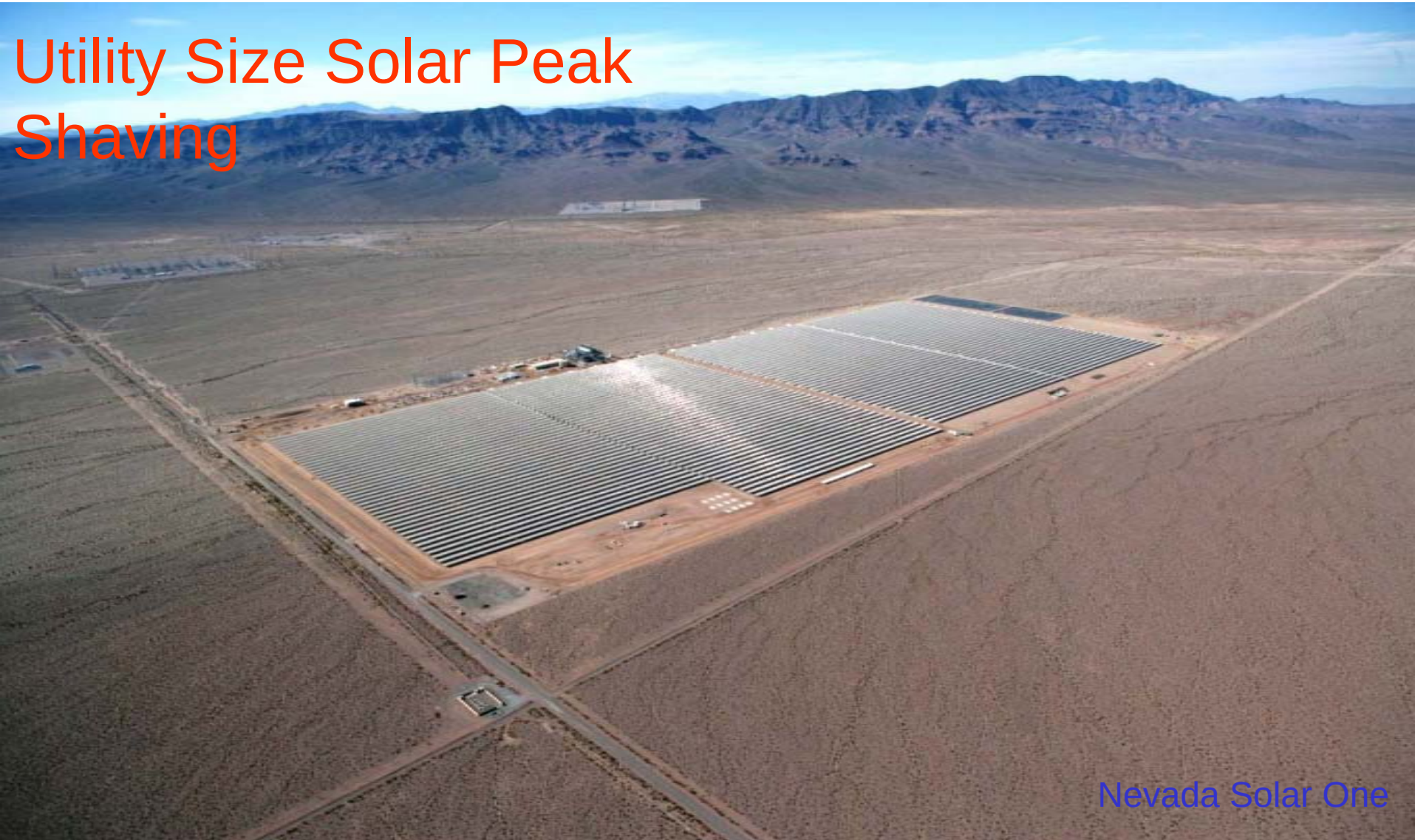


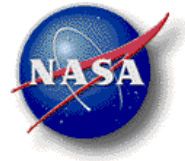
Battery capacity of 100kWh will be discharged in 1 hr, twice a day

System's Energy Production



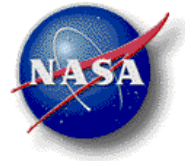
Alternate Energy





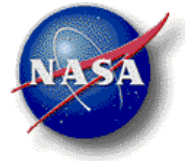
Peak Shaving Solar Plant

- **NASA owns land at White Sands and could be available for a solar power generation plant**
  - **Approximately 400 acres**
  - **Existing injection and monitoring wells that NASA will need full access to (including drilling rigs)**
- **Plant will be built and operated by the developer.**
- **Developer is responsible for <u>ALL</u> financing of design, construction and operation.**



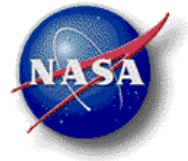
Peak Shaving Solar Plant

- **Current Electrical Power to WSTF**
  - **69kV Transmission line to Apollo Substation from El Paso Electric Company**
  - **24kV distribution line down to NASA land area**
  - **Substation rated for 15MW**
- **NASA desires power to support site**
  - **Currently NASA has a ~5.5MW peak load**
  - **DOD Installation on-site is also interested in renewable energy**



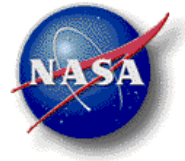
Peak Shaving Solar Plant

- **Preliminary Environmental Assessment (EA) has been completed, but a complete EA is required prior to construction start**
- **NASA facility-type support is available, but a cost will be associated with this support**



Peak Shaving Solar Plant

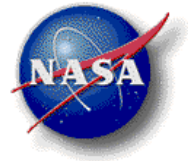
- **RFI on GovBiz (14 responses)**
  - **Number:2008LUA**
  - **Posted Date: May 14, 2008**
  - **Response Date: May 27, 2008**
  - **14 responses recieved**
- **Industry day on Aug 12, 2008**
  - **MMA Renewable Ventures, LLC**
  - **Abencs/Abengoa**
  - **Acciona**
  - **International Power America**
  - **EverGuard Roofing, LLC**
  - **Greenlight Sunstream Holdings, LLC (dba Helios Energy)**
  - **Consolidated Solar Technologies**
  - **North Wind Inc**
  - **Juwi Solar**



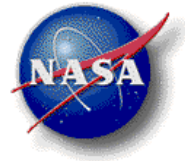
Peak Shaving Solar Plant

- **New website for vendors has been generated. We are in the process of posting project information and Q&A**
- **Working with NREL an NMSU on the RFP (late October)**
- **Options going forward:**
  - **Provide land to EPEC for 92 MW CSP plant (E-Solar)**
  - **Sell power to PNM or other NM utilities**
  - **Sell power out of state**
  - **Use power only behind the meter (NASA, WSMR, HAFB, Fort Bliss)**

Questions?

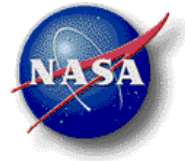


Backup Slides



Component Description

- **PV Solar Modules:** 189 total, 265Wp each. Will provide shade for 1,200 m^2 (~13000 ft^2).
- **Balance of Systems**
  - 2 Power Conditioning Unit for battery voltage control to manage power delivery bi-directional. Manage the charge and discharge rates of battery and ensure compliance with utility harmonics standards.
- **Inverter:** Utility Interactive 50kW rating
  - Zinc Bromine Battery package has integrated utility inverter built in.
- **Batteries (Zinc Bromine):** 2-50kW battery bank for Total of 100kWh storage capacity.
  - Batteries will be programmed to discharge during customer peak (weekday) usage, thereby reducing customer demand charges.
- **Data Acquisition System**
  - The DAS system will monitor real-time PV production, customer load, battery State of Charge, Charging and Discharging voltages and currents.
  - Campbell Scientific datalogger



Energy Production Summary

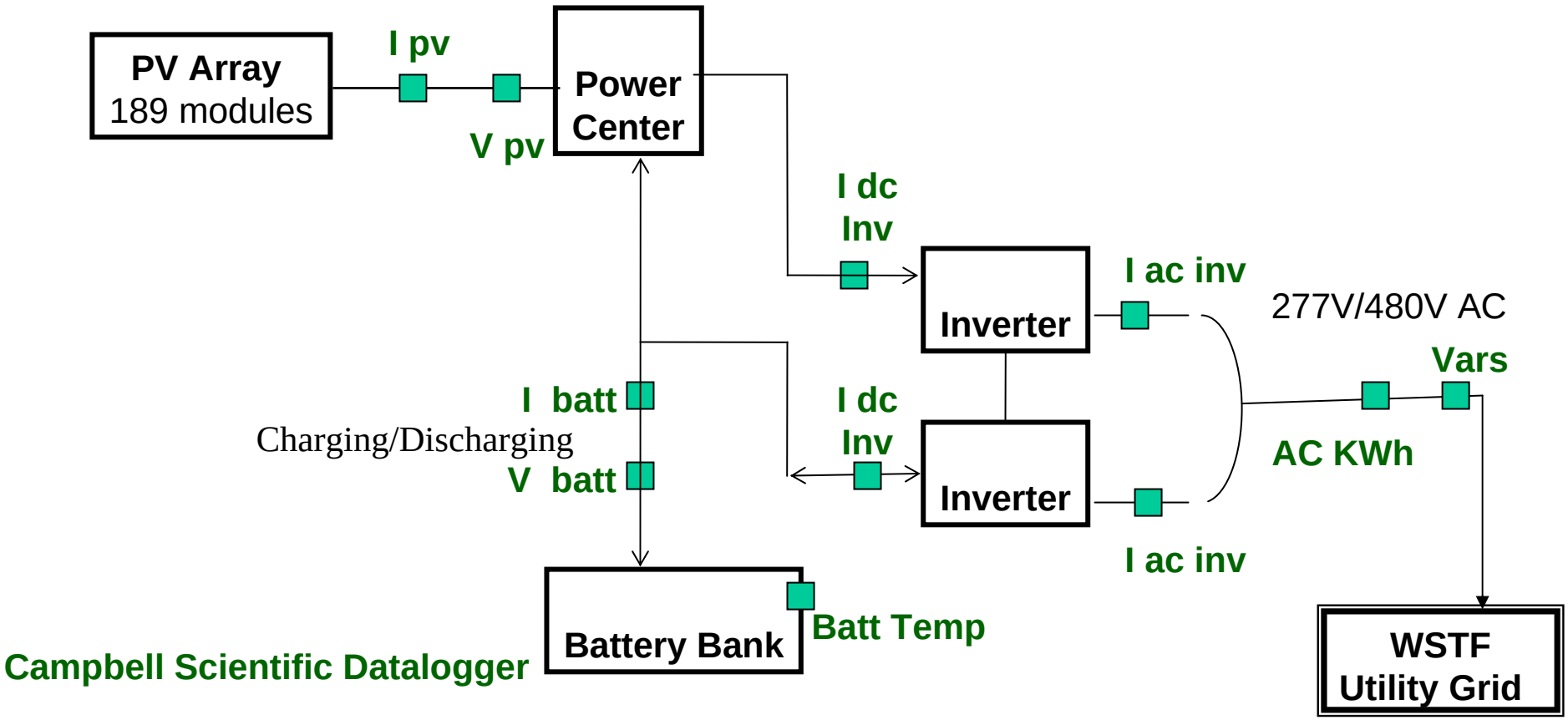
PV Production		
Quantity	**Value**	**Units**
Rated Capacity	50	kW
Mean Output	294	kWh/day
Capacity Factor	24.5	%
Total Production	94426	kWh/year

Battery		
Quantity	**Value**	**Units**
Rated Capacity	50	kW
Usable Storage Capacity	100	kW
Discharging	4	Hr
Energy Out	154	kWh/day
Round Trip Efficiency	77	%
Battery losses	23	%

Environmental Benefits - Emissions		
Pollutant	**Value**	**Units**
Carbon Dioxide	36,557	Kg/yr
Carbon Monoxide	0	Kg/yr
Sulfur dioxide	158	Kg/yr
Nitrogen Oxide	77.5	Kg/yr

System Performance Monitoring

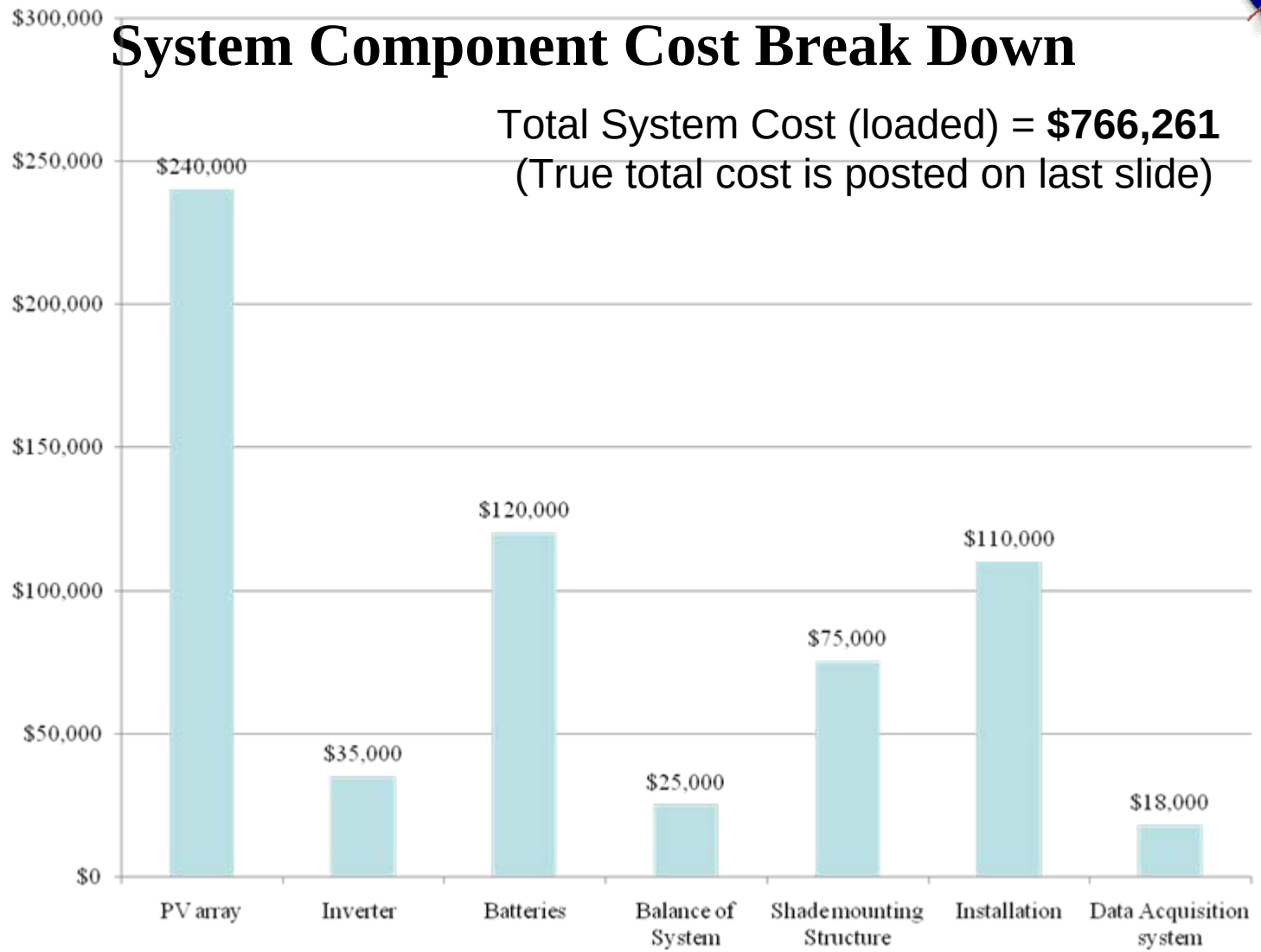
Data Acquisition System Parameters -One line diagram



- Other Sensors
  - Solar Irradiance
- Ambient Temperature

System Component Cost Break Down

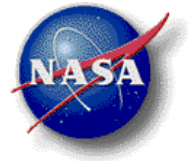
Total System Cost (loaded) = **$766,261**
(True total cost is posted on last slide)



Note: Costs displayed for each component is NOT loaded

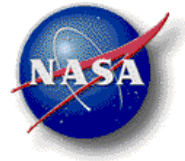
Summary

System Architecture	
Total Area	1,200 m² (~13,000 ft²)
PV Array Rating	50 kW (approx. 189 PV modules of 265Wp)
Battery Bank	100 kWh Capacity (2 – 50kW modules)
Cost Break Down	
PV Array Modules	$240K
Inverter	$35K
Batteries Zinc Bromine	$120K
Balance of System	$25K (2 power conditioning unit)
Shade Parking Structure	$75K (~$20k to $30k per 18kW array)
Installation	$110K
Data Acquisition System	$18K (hardware only)
Cost Per Watt Installed	$12.46/Watt (PV/Battery application--$8/Watt PV only)
Total Loaded Cost of System	**$766,261**
Annual Energy Production	
AC Energy Production	94,426 kWH (output of PV/Battery System)
* Capacity Factor	24.0%
Levelized Cost of Energy	$0.25 kW/H (cost to produce energy kWh)



New Technologies

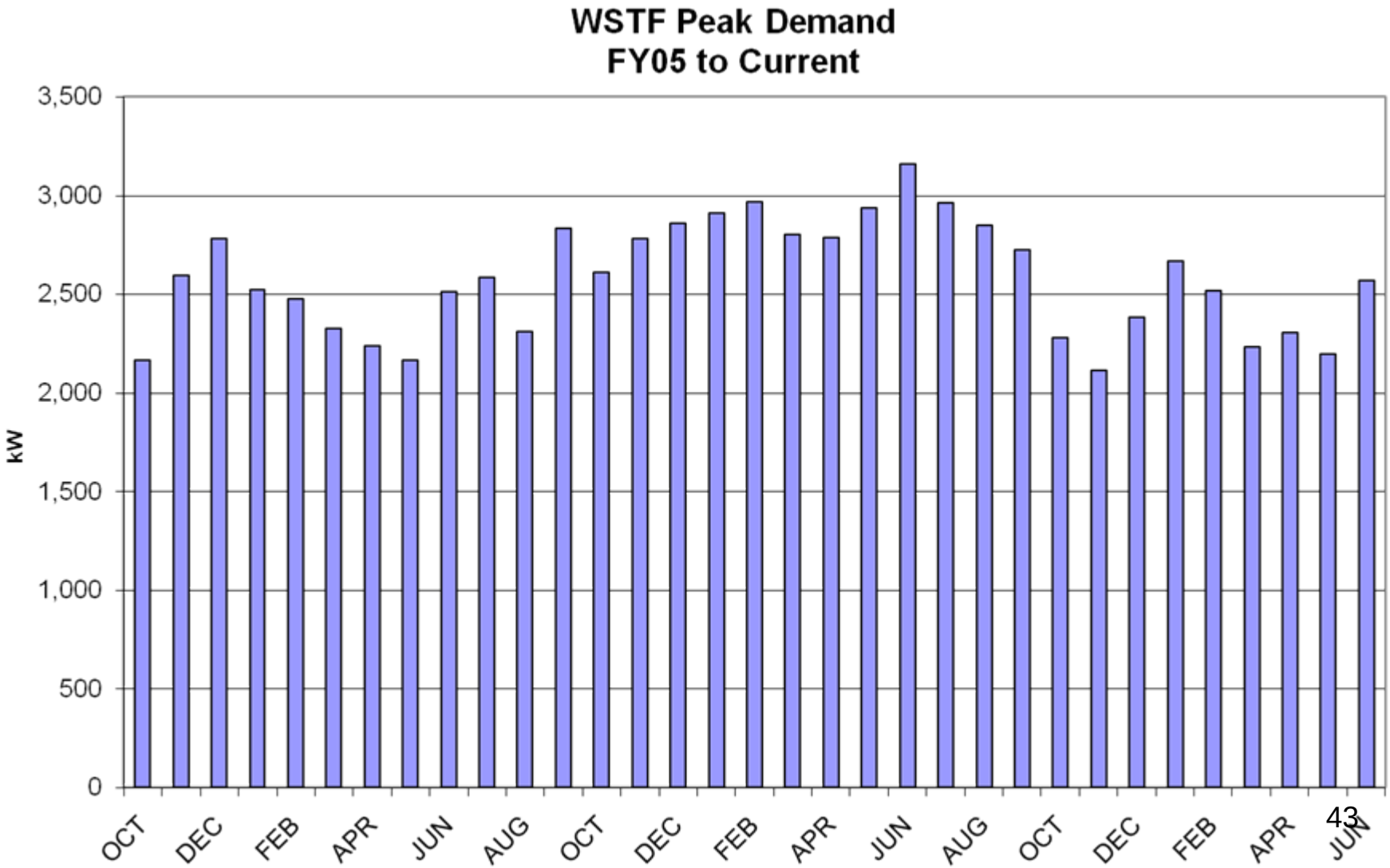
- Implement Renewable Initiatives by combining the best technologies to arrive at most efficient system(s):
  - Solar power PV system
  - Geothermal heat pump systems
  - Wind generated power
  - Solar powered thermal system
  - Hydrogen
  - Fuel cells
  - Hybrid systems



5 Year Long Term Goals

- Develop a Solar Powered PV farm for providing electrical power to WSTF and sell surplus power to utility companies.
- Develop 3MW of wind generated power with wind farm on top of Quartzite Mt.
- Utilize geothermal heat pump systems for WSTF facilities heating and cooling to greatly reduce utility costs.
- Provide renewable energy test beds for supporting future Orion energy requirements.

Facilities Peak Demand Load



Facility's Peak Demand and PV System Production